Public Choice Game

In-Class Experiment

The Effect of Communication on Public Good Investments

EC.438 Experimental Economics

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ABSTRACT

Since the contribution of societies in using public goods and their benefits are not interrelated, it creates an injustice and prevents the economic benefit from being at the maximum level. We think that communication is the way to prevent this free-rider problem. In our experiment to prove this, we asked people to put their investment into maximizing group profits, and we analyzed the results by simply changing the communication factor in two different parts of the experiment. We also looked at the quality of communication and scored correspondence between group members to see what caused the cooperation and noncooperation path. Although the communication has a positive effect, we have seen that the insecurity has increased in the ongoing game and the free-riding continues and ends at similar points.

Keywords: Free-rider, communication, public goods, experiment, sentiment analysis

Introduction

In the economy, a public good (also called social good or collective good) cannot be excluded as well as unrivaled. For such goods, users cannot be prevented from accessing or using them as they do not pay. In addition, one person's use neither prevents other people's access nor reduces others' access. Typically, these services are managed by governments and are paid collectively by taxation. Due to their nature, the contribution to these goods may not be directly proportional to the benefit obtained from these goods. The Pareto optimal solution for individuals, in this case, is to make the maximum contribution, assuming everyone's endowments and marginal per capita returns (MPCR) in the society are equal, but the Nash equilibrium is making zero contribution. Because of the nature of the problem, society cannot get the maximum benefit from public goods. As a result, a problem arises from diminishing potential utility.

Economists, policy-makers, and thinkers have thought of many ways to solve this problem. Although these ways for policymakers are to regulate the use of public goods or to make contributions compulsory by-laws, it is economists who examine the main solutions for deep reasons. With the studies of social psychology, behavioral economics, and experimental economics, optimum solutions, the ways in which free-riding is minimized, have been revealed.

The first of these ways is the method of punishment. With the penalty, it is assumed that individuals will agree to contribute because they will lose their income in scenarios

where they remain free-riders. In this area; Yamagishi (1986), Fehr and Gächter (2002), and Bowles and Gintis (2002) found that punishment led to significant increases in maximizing public interest by punishing free riders.
On the other hand, economists arguing that communication, as well as punishment, will solve problems, have produced studies that prove this. Thanks to communication, society, whose behavior changes, learns more accurately in obtaining the maximum benefit of cooperation. Therefore, the impact of communication on public good investments is worth thinking about which is the main question of our experiment.

Dawes, McTavish, and Shaklee (1977) show that in scenarios where group members communicate in their experiment on a group, in a one-step version of a bilateral decisive public goods game (in which subjects have to choose between cooperating or not) cooperation can be significantly improved. As a result of the experiment, if communication is not provided, there is a 73% defect rate or 65% defect rate was determined in unrelated communication conditions, but if communication is achieved, the defect rate drops to 26%, and the free-rider is thus minimized.

Isaac and Walker (1988) examined the variable that we have also considered in our article and in our experiment. Experiments and results are parallel. Through their experiment, Isaac and Walker (1988) demonstrated that cooperation with communication increased. There are two different scenarios in his experiments. In the first scenario, it was expected to contribute without communication in the first 10 of the 20-round experiment, and in the remaining 10 rounds, first communication was established and then anonymously. In another scenario, on the contrary, communication was established in the first 10 rounds and an anonymous floor was provided, but it is expected to contribute without communication in the last 10 rounds.

Isaac and Walker (1988) found positive results for behavioral economics and social psychology as a result of their research. The contribution of those who started the game without communicating increased after they communicated. This reveals how effective communication is to prevent free-riding in public goods. In addition, in the second scenario, individuals have provided an atmosphere of trust in the first 10 rounds thanks to communication and free-riding has been prevented to a great extent, and people have continued to make a high contribution in the remaining 10 rounds. In other words, from the point of view of a social psychologist, people have established and maintained an atmosphere of trust through communication. However, economists have also seen that they are minimizing free-riding.

As a result, it has been shown that how much free-riding can be reduced to a minimum level with communication in experiments. In order to compare this in our experiment, we will examine whether the social benefit from public goods can be increased by simply adding the communication variable. In the future, we will explain the procedure of our experiment, our theories and hypotheses, the analysis of the data from our experiment, and as a result, what the experiment proves to us.

Procedure

The experiment took place in an online zoom session and online Veconlab session with 40 participants. All participants were either junior or senior students of Bogazici University who enrolled in the EC 438 Experimental Economics course. All participants were Turkish students, and they understood English as well. Participants joined the experiment via the Veconlab link. Each participant had their ID and they joined the experiment with their name in order to identify attendance of the lecture but their original names are omitted for privacy. In the first treatment of the experiment, the players cannot get in contact with their group members but in the second treatment communication between group members is allowed. Instructions were given by Veconlab itself and experimenters did not give further instructions to avoid bias. In the experiment, there are ten groups which consist of fixed four participants for every two treatments.

Without Chat				With Chat			
Treatment 1				Treatment 2			
Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4

Participants had $100 worth of tokens at each round and were asked how much money they wanted to keep or invest in public goods. Participants cannot see other participants' decisions until it is all submitted. If the player kept their tokens, his/her earnings would be the doubled token number they kept. Another earning method is for players to get tokens from the total contribution amount made by group members.

Earnings	
Kept Earnings	**Contribution Earnings**
2 x Kept Amount	Total contribution made by group members

Theory

The general theoretical model for the Public Good Game in this experiment is adapted from "Public Goods Provision in an Experimental Environment" by Isaac, McCue, and Plott (1982). The public good game is designed with n players who simultaneously choose their actions c_i out of their endowment levels that is e_i with considering α_i which is marginal per capita returns (MPCR).

$$i \in \{1, 2, \ldots, n\}$$

c_i = Contribution of players out of their own endowments to a group account.

e_i = Endowment level

α_i =MPCR

Therefore, the individual earnings are:

$$\pi_i = e_i - c_i + \alpha_i \sum_J c_j$$

Since we are controlling the impact of communication in public good game, we kept α_i constant for all participants in our setting. Therefore,

$$\alpha_i = \alpha \text{ for } i \in \{1, 2, \ldots, n\}$$

$$\pi_i = e_i - c_i + \alpha \sum_J c_j$$

i) If $\alpha * n > 1$ *and* $\alpha < 1$, $c_i = e_i$ is the pareto optimal strategy but backward induction results show that $c_i = 0$ is the unique Nash equilibrium.

ii) If $\alpha * n < 1, C = 0$ is the pareto optimal strategy and the unique Nash equilibrium.

iii) If $\alpha \geq 1$, $c_i = e_i$ is the pareto optimal strategy and the unique Nash equilibrium.

Deviations from these equilibria can be observed because of social preferences which are altruism and reciprocity and misunderstanding the game (Durlauf and Blume, 2012).

According to the theory of public good game and results of previous experiments which are conducted by Dawes et al. in 1977 and Isaac et al. in 1982, communication in public good game experiment leads to small and stable increases the level of contribution c_i.

Hypotheses

In this experiment, the players decide contribution amounts. There are two treatments each with four rounds and fixed groups. The endowments, the internal returns, and the external returns. The only difference between the two treatments is the communication between players in a group member with a limited one-minute time. It is expected when communication is allowed players tend to cooperate to earn higher payoffs in the second treatment. However, as the rounds progress, it is expected the average contributions of players to move towards the Nash Equilibrium point. The other expectation from the experiment is to observe the relationship between sentiment scores of the chat data and contribution levels. The sentiment scores are generated from the correspondences between group members and scored between 0 (noncooperation) and 10 (cooperation) according to cooperation communication among group members. This chat data is scored manually due to the use of many abbreviations and miswriting. In order to prevent any bias, the scoring is made without looking at the contributions of players.

I. H_0: Communication does not affect contribution levels.

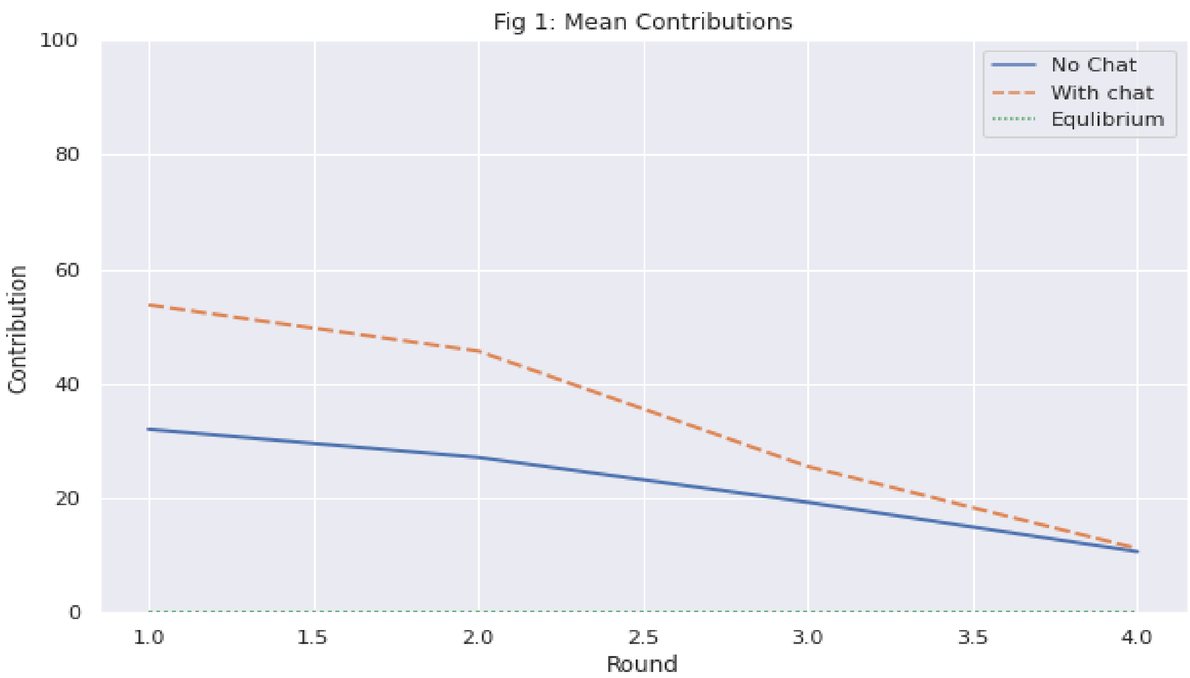
H_1: Communication affects contribution levels.

II. H_0: Sentiment Scores have no relationship with contribution levels.

H_1: Sentiment Scores have a relationship with contribution levels.

Results

As mentioned, our experiment consists of two treatments: non-communication / communication (NC / C). We will examine the economic ethics and social learning of individuals with asymmetric knowledge and anonymous endowment in the light of data. Let's examine the data we collect both numerically and their meanings; First, let's see a few features of the data we have (Exploratory Data Analysis). The change of the average contributions according to rounds will be useful to see the overall picture so we will first examine this data:

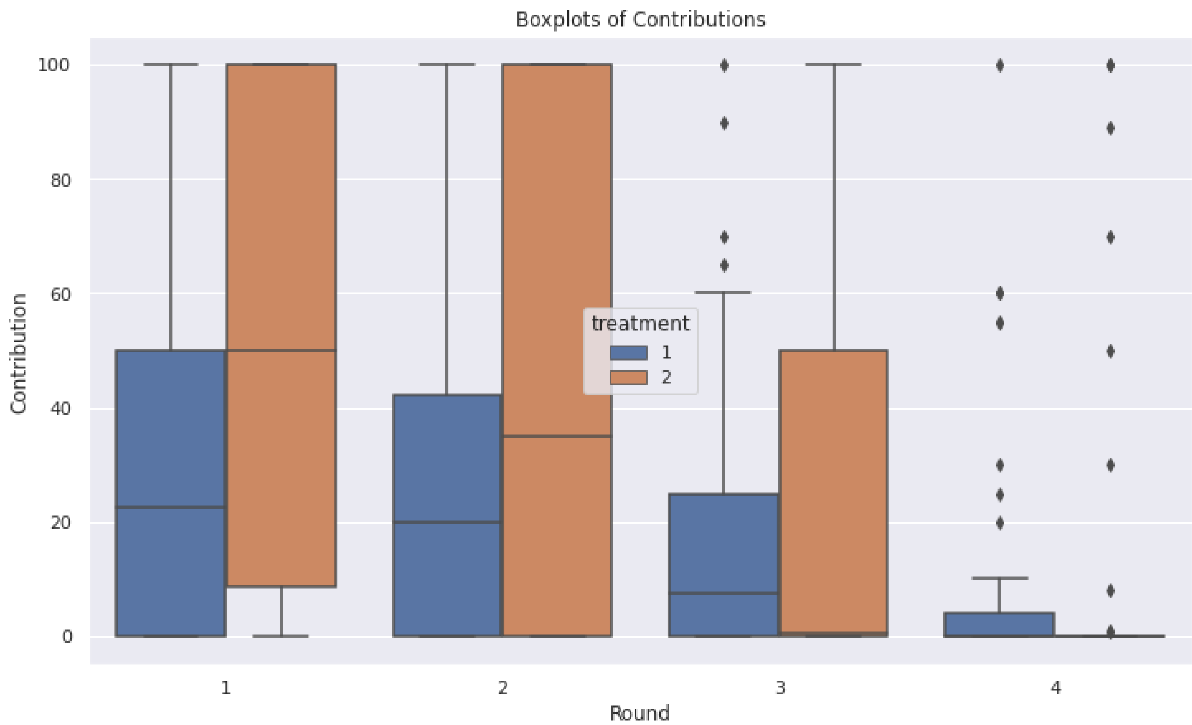


Although the Pareto Optimal result of the experiment is the maximum contribution of each individual, it will be the most risky option to contribute zero to the individuals in avoiding a potential work union, because of this, we can see a convergence to 0 contribution which is the Nash equilibrium for both treatments.

At second treatment players started with high contribution levels but it converged to equilibrium number faster than the first treatment. That effect might be the feeling of being deceived by other group members which leads us to the second hypothesis. We need to look at chat data to understand this hypothesis.

Now let's compare the characteristics of contribution statistics. In order to inspect all median, variance, and distribution of data on the same plot use box-plot for contributions. In the plot below treatment 1 is no-chat case and chat is allowed in treatment 2.

Figure 2



For first rounds, the variance is higher at the second treatment which means players acting differently than each other. Some of them could be affected by chat, however, on the other hand some players continue to pursue the equilibrium strategy. However, for Treatment 2, the variance in the first round is higher than the Treatment1, people behaved differently from each other (who are affected by chat). But for the last Rounds of Treatment2, people who have behaved similarly to these rounds will be useful to examine what is returning to Chat. It will be useful to use the Sentiment Score of Chats for this analysis. (For figure 3 below, sentiment score 10: most cooperative and 0: non-cooperative)

Figure 3: Mean Sentiment Scores

In Treatment2, the participants had the possibility to act together thanks to the chat box, but when cooperation decreases, we see participants are more prone to invest in or reduce their investment. It seems that the variance decreases with the chat data, because the increase in non-cooperative discourse has persuaded many people to invest in low investment and at near to the point of equilibrium. This is the basis that leads us to hypothesis 2.

Hypothesis 1:

As indicated in the hypothesis section the null hypothesis indicates that communication does not affect contribution levels. In order to observe the effect of communication on contribution, we set panel data regression and regressed contribution as a dependent variable on is_chat (0 for treatment 1, 1 for treatment 2) as an explanatory variable. Also, rounds (round_1, round_2, round_3, round_4) are added as dummy variables to not face multicollinearity and eliminate the fixed effects of panel data. Then, to identify the type of experiment model (fixed effects or random effects), we controlled the Hausman

Test result and the result showed that the model of experiment is a fixed effects model . Therefore in order to run a fixed effect panel data model we added rounds and individuals as a dummy variable to the model. The fixed effect regression results are as follows:

Figure 4

OLS Regression Results

Dep. Variable:	Contribution	**R-squared:**	0.445
Model:	OLS	**Adj. R-squared:**	0.358
Method:	Least Squares	**F-statistic:**	5.145
Date:	Sun, 23 May 2021	**Prob (F-statistic):**	1.21e-17
Time:	21:28:22	**Log-Likelihood:**	-1510.5
No. Observations:	320	**AIC:**	3109.
Df Residuals:	276	**BIC:**	3275.
Df Model:	43		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
round_1	19.0857	2.867	6.658	0.000	13.442	24.729
round_2	12.6232	2.867	4.403	0.000	6.980	18.267
round_3	-1.3768	2.867	-0.480	0.631	-7.020	4.267
round_4	-12.8518	2.867	-4.483	0.000	-18.495	-7.208
1	26.0151	10.206	2.549	0.011	5.923	46.107
2	-27.3599	10.206	-2.681	0.008	-47.452	-7.268
3	-27.6099	10.206	-2.705	0.007	-47.702	-7.518
4	1.0151	10.206	0.099	0.921	-19.077	21.107
5	-6.4849	10.206	-0.635	0.526	-26.577	13.607
6	-14.3599	10.206	-1.407	0.161	-34.452	5.732

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37	-0.2349	10.206	-0.023	0.982	-20.327	19.857
38	13.2651	10.206	1.300	0.195	-6.827	33.357
39	22.2651	10.206	2.182	0.030	2.173	42.357
40	-27.7349	10.206	-2.717	0.007	-47.827	-7.643
constant	17.4804	1.813	9.643	0.000	13.912	21.049
is_chat	11.7688	3.269	3.601	0.000	5.334	18.203

Omnibus:	11.744	**Durbin-Watson:**	1.893
Prob(Omnibus):	0.003	**Jarque-Bera (JB):**	12.278
Skew:	0.479	**Prob(JB):**	0.00216
Kurtosis:	3.038	**Cond. No.**	1.80e+16

Since the coefficients for dummy variables indicating the participants do not carry important information, those are not presented in the table above. The important regressor for us is is_chat. The coefficient of is_chat variable is 11.7688 which means that providing chat opportunities to participants increases the tendency to contribute 11%. We have 0 p-value for 95% confidence interval which shows is_chat variable is statistically significant. Therefore, we can conclude that chat has a positive impact on contributions. Once we found chat is effective to increase contributions, the next question that comes to mind is what is talked about in groups and how does the content of chat have impact on contributions. This question brings us to the second hypothesis which states that the sentiment scores have no relationship with contribution levels.

Hypothesis 2:

As indicated in the hypothesis section the null hypothesis indicates that sentiment scores have no relationship with contribution levels. In order to observe the effect of sentiment scores on contribution, we set panel data regression and regressed contribution as a dependent variable on cooperation_score that is scored between 0 (cooperation) and 10 (cooperation) as an explanatory variable. Also, rounds (round_1, round_2, round_3, round_4) and individuals are added as dummy variables to not face multicollinearity and handle the fixed effects for panel data. Then, to identify the type of experiment model (fixed effects or random effects), we controlled the Hausman Test result and the result showed that the model of experiment is a fixed effects model. We have sentiment scores only for treatment 2, since chat is not provided in treatment 1 we have only fixed effects for rounds and individuals. In treatment 2 we have also the impact of sentiment scores, mathematically,

The general equation can be written as:

$$y_{it1} = \beta_0 + \beta_1 score + F_i + T_t + u_{it}$$

$$\text{Tr1: } y_{it1} = \beta_0 + F_i + T_t + u_{it}$$

$$\text{Tr2:} y_{it2} = \beta_0 + \beta_1 score + F_i + T_t + u_{it}$$

Take the difference of the equations of treatments we get:

$$y_{it1} - y_{it2} = \beta_1 score + u_{it3}$$

When we run the regression above we get the results below:

Figure 5

OLS Regression Results

Dep. Variable:	Contribution	**R-squared (uncentered):**	0.111
Model:	OLS	**Adj. R-squared (uncentered):**	0.105
Method:	Least Squares	**F-statistic:**	19.86
Date:	Sun, 23 May 2021	**Prob (F-statistic):**	1.56e-05
Time:	20:40:16	**Log-Likelihood:**	-820.08
No. Observations:	160	**AIC:**	1642.
Df Residuals:	159	**BIC:**	1645.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
sent_score	2.3384	0.525	4.457	0.000	1.302	3.375

Omnibus:	5.893	**Durbin-Watson:**	2.013
Prob(Omnibus):	0.053	**Jarque-Bera (JB):**	5.600
Skew:	0.451	**Prob(JB):**	0.0608
Kurtosis:	3.163	**Cond. No.**	1.00

We can observe the positive relationship between the sentiment scores and differenced contributions. The difference of contributions is the main indicator for the impact of chat on contributions since it is the only difference between treatments. Since we can observe the sentiment scores and differenced contributions have positive relationships significantly, we can say that the content of the chat is important to increase the contributions. As a result, for our second hypothesis we concluded with the rejection of the Null hypothesis, in other words, sentiment scores affect the contribution levels.

Conclusion

Our results confirm that free-riding behavior is observed less when communication among group members is allowed. We deduce that the decreasing free-riding behavior is statistically significant. However, the change has no power to create any deviation from the Nash equilibrium since the contribution amount is decreasing while the rounds are playing. Also, our results are consistent with the Croson R.T.A. (2010) and the first version of Isaac et al paper "Provision in an Experimental Environment" in 1982 results but inconsistent with the second version of this paper in 1985. The inconsistency comes from two reasons. The first one is the type of communication. In our experiment, the effect of communication is tested by correspondence among group members but in the treatment of Isaac et al. (1985), the effect is tested by face-to-face communication so we consider that face-to-face communication makes cooperation easier than the correspondence way. The other reason is the number of rounds. In our treatment, there are four rounds for each treatment but in the treatment of Isaac et al (1985) the number of rounds is ten. However, in treatment 2 of our experiment, the trend of contributions converges to the Nash equilibrium point (zero contribution) while the contributions of the treatment of Isaac et al (1985) are always near to the Pareto optimal point (full contribution). In summary, we can deduce that communication with the correspondence decreases the free-riding and increasing the amount of contribution but it cannot change the decreasing trend of contribution as the rounds progress and we also conclude that type of communication should be applied and the number of rounds should be increased to get a proper understanding for the effects of communication on the contribution. For the second hypothesis we looked for the relationship between sentiment scores of chat data and the contributions. We found sentiment scores to be significantly increasing the contribution levels after running a regression with differenced values of contributions in two treatments. Therefore, we found that in addition to the existence of chat the content of chat data is also important to increase contribution levels.

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Appendix 1: (Raw Data)

treatment	Round	ID	Contribution	cooperation_score
1	1	1	25	
1	1	2	0	
1	1	3	0	
1	1	4	50	
1	1	5	0	
1	1	6	7	
1	1	7	0	
1	1	8	100	
1	1	9	45	
1	1	10	20	
1	1	11	0	
1	1	12	35	
1	1	13	50	
1	1	14	20	
1	1	15	0	
1	1	16	60	
1	1	17	40	
1	1	18	75	
1	1	19	10	

1	1	20	60	
1	1	21	93	
1	1	22	50	
1	1	23	0	
1	1	24	79	
1	1	25	20	
1	1	26	50	
1	1	27	2	
1	1	28	30	
1	1	29	100	
1	1	30	20	
1	1	31	20	
1	1	32	50	
1	1	33	10	
1	1	34	70	
1	1	35	0	
1	1	36	50	
1	1	37	0	
1	1	38	40	
1	1	39	0	
1	1	40	0	
1	2	1	50	
1	2	2	0	
1	2	3	0	
1	2	4	40	
1	2	5	0	
1	2	6	0	
1	2	7	0	
1	2	8	49	
1	2	9	30	
1	2	10	30	
1	2	11	0	
1	2	12	30	

1	2	13	10	
1	2	14	18	
1	2	15	0	
1	2	16	60	
1	2	17	30	
1	2	18	50	
1	2	19	20	
1	2	20	10	
1	2	21	25	
1	2	22	60	
1	2	23	0	
1	2	24	40	
1	2	25	10	
1	2	26	50	
1	2	27	1	
1	2	28	35	
1	2	29	100	
1	2	30	20	
1	2	31	20	
1	2	32	50	
1	2	33	5	
1	2	34	100	
1	2	35	0	
1	2	36	100	
1	2	37	10	
1	2	38	33	
1	2	39	0	
1	2	40	0	
1	3	1	100	
1	3	2	0	
1	3	3	0	
1	3	4	0	
1	3	5	0	

1	3	6	0	
1	3	7	0	
1	3	8	0	
1	3	9	10	
1	3	10	0	
1	3	11	0	
1	3	12	20	
1	3	13	20	
1	3	14	10	
1	3	15	0	
1	3	16	60	
1	3	17	60	
1	3	18	25	
1	3	19	5	
1	3	20	10	
1	3	21	0	
1	3	22	70	
1	3	23	0	
1	3	24	0	
1	3	25	50	
1	3	26	10	
1	3	27	0	
1	3	28	20	
1	3	29	10	
1	3	30	10	
1	3	31	25	
1	3	32	65	
1	3	33	2	
1	3	34	90	
1	3	35	0	
1	3	36	50	
1	3	37	0	
1	3	38	50	

1	3	39	0	
1	3	40	0	
1	4	1	55	
1	4	2	0	
1	4	3	0	
1	4	4	10	
1	4	5	0	
1	4	6	0	
1	4	7	0	
1	4	8	0	
1	4	9	0	
1	4	10	0	
1	4	11	0	
1	4	12	0	
1	4	13	20	
1	4	14	0	
1	4	15	0	
1	4	16	60	
1	4	17	0	
1	4	18	25	
1	4	19	0	
1	4	20	0	
1	4	21	2	
1	4	22	60	
1	4	23	0	
1	4	24	0	
1	4	25	0	
1	4	26	0	
1	4	27	0	
1	4	28	0	
1	4	29	0	
1	4	30	10	
1	4	31	0	

1	4	32	0	
1	4	33	30	
1	4	34	100	
1	4	35	0	
1	4	36	0	
1	4	37	0	
1	4	38	55	
1	4	39	0	
1	4	40	0	
2	1	1	100	9
2	1	2	0	9
2	1	3	0	5,5
2	1	4	100	5,5
2	1	5	100	8
2	1	6	100	9
2	1	7	0	8
2	1	8	100	9,5
2	1	9	100	10
2	1	10	100	10
2	1	11	100	8,5
2	1	12	50	8
2	1	13	20	6
2	1	14	15	5,5
2	1	15	0	7
2	1	16	100	7
2	1	17	0	7
2	1	18	100	8,5
2	1	19	5	7
2	1	20	10	9,5
2	1	21	10	8
2	1	22	50	8
2	1	23	0	5,5
2	1	24	100	8

2	1	25	100	10
2	1	26	5	10
2	1	27	30	9
2	1	28	100	9
2	1	29	100	9
2	1	30	10	9,5
2	1	31	100	9,5
2	1	32	100	8,5
2	1	33	5	8
2	1	34	60	9
2	1	35	50	8,5
2	1	36	50	6
2	1	37	10	9
2	1	38	70	6
2	1	39	100	8
2	1	40	0	6
2	2	1	100	5
2	2	2	0	5
2	2	3	1	7,5
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2	2	26	100	7
2	2	27	100	7
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2	4	30	0	0
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2	4	35	0	1,5
2	4	36	0	0

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2	4	38	0	0
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